

# RF Power Field Effect Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

Designed for W-CDMA base station applications with frequencies from 2110 to 2170 MHz. Suitable for TDMA, CDMA and multicarrier amplifier applications. To be used in Class AB for PCN-PCS/cellular radio and WLL applications.

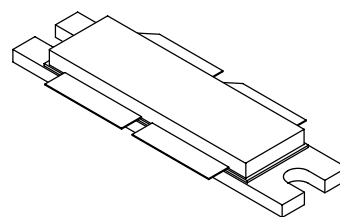
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 2200$  mA,  $P_{out} = 52$  Watts Avg.,  $f = 2157.5$  MHz, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 13 dB  
Drain Efficiency — 24%  
IM3 @ 10 MHz Offset — -36 dBc in 3.84 MHz Channel Bandwidth  
ACPR @ 5 MHz Offset — -39 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 5:1 VSWR, @ 28 Vdc, 2140 MHz, 180 Watts CW Output Power

### Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- Lower Thermal Resistance Package
- Low Gold Plating Thickness on Leads, 40 $\mu$ " Nominal.
- RoHS Compliant
- In Tape and Reel. R6 Suffix = 150 Units per 56 mm, 13 inch Reel.

**MRF5P21240HR6**

**2110-2170 MHz, 52 W AVG., 28 V**  
**2 x W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFET**



**CASE 375D-05, STYLE 1**  
**NI-1230**

**Table 1. Maximum Ratings**

| Rating                                                                                 | Symbol    | Value        | Unit                     |
|----------------------------------------------------------------------------------------|-----------|--------------|--------------------------|
| Drain-Source Voltage                                                                   | $V_{DSS}$ | -0.5, +65    | Vdc                      |
| Gate-Source Voltage                                                                    | $V_{GS}$  | -0.5, +15    | Vdc                      |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$     | 603<br>3.4   | W<br>W/ $^\circ\text{C}$ |
| Storage Temperature Range                                                              | $T_{stg}$ | - 65 to +150 | $^\circ\text{C}$         |
| Case Operating Temperature                                                             | $T_C$     | 150          | $^\circ\text{C}$         |
| Operating Junction Temperature                                                         | $T_J$     | 200          | $^\circ\text{C}$         |
| CW Operation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$             | CW        | 200<br>1.18  | W<br>W/ $^\circ\text{C}$ |

**Table 2. Thermal Characteristics**

| Characteristic                                                                                                                          | Symbol          | Value (1,2)  | Unit               |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------|--------------|--------------------|
| Thermal Resistance, Junction to Case<br>Case Temperature $82^\circ\text{C}$ , 180 W CW<br>Case Temperature $77^\circ\text{C}$ , 52 W CW | $R_{\theta JC}$ | 0.29<br>0.32 | $^\circ\text{C/W}$ |

1. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

**Table 3. ESD Protection Characteristics**

| Test Conditions                       | Class        |
|---------------------------------------|--------------|
| Human Body Model (per JESD22-A114)    | 2 (Minimum)  |
| Machine Model (per EIA/JESD22-A115)   | M3 (Minimum) |
| Charge Device Model (per JESD22-C101) | C6 (Minimum) |

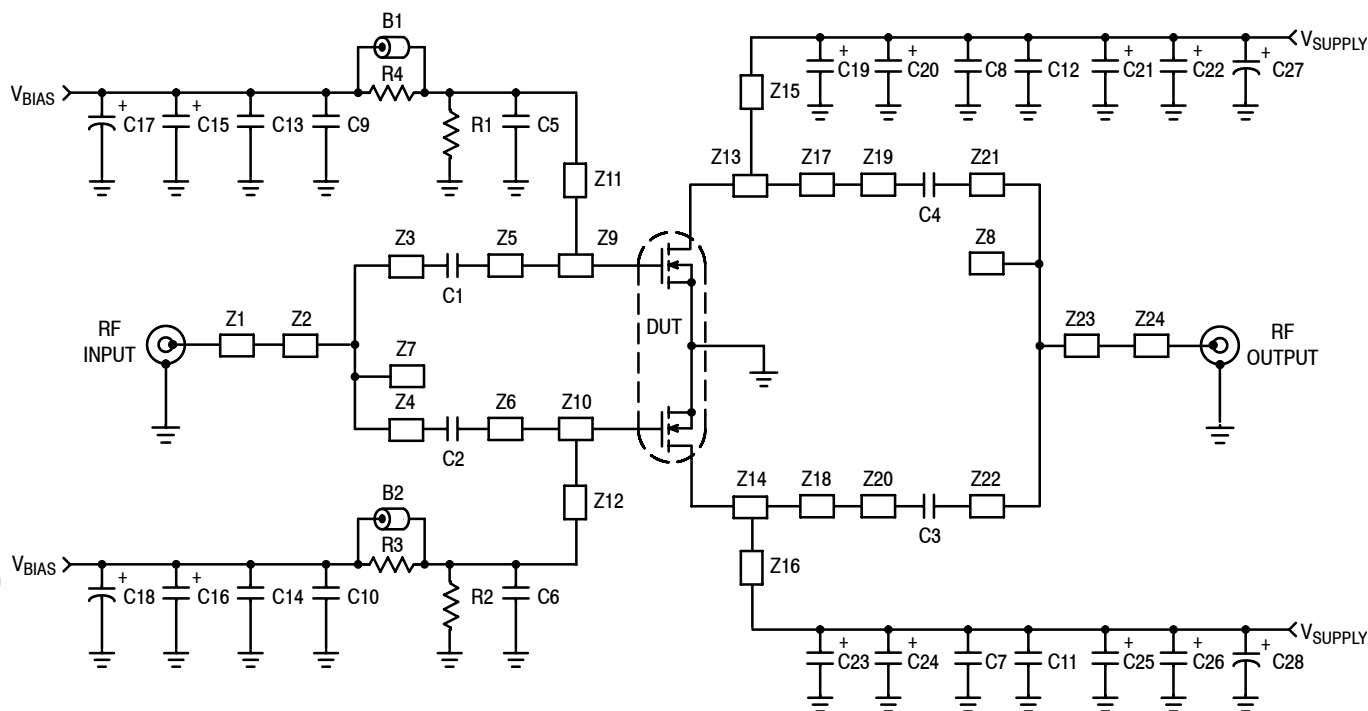
**Table 4. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

| Characteristic                                                                                           | Symbol       | Min | Typ  | Max | Unit            |
|----------------------------------------------------------------------------------------------------------|--------------|-----|------|-----|-----------------|
| <b>Off Characteristics</b> <sup>(1)</sup>                                                                |              |     |      |     |                 |
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )        | $I_{DSS}$    | —   | —    | 10  | $\mu\text{Adc}$ |
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )        | $I_{DSS}$    | —   | —    | 1   | $\mu\text{Adc}$ |
| Gate-Source Leakage Current<br>( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )                     | $I_{GSS}$    | —   | —    | 1   | $\mu\text{Adc}$ |
| <b>On Characteristics</b>                                                                                |              |     |      |     |                 |
| Gate Threshold Voltage <sup>(1)</sup><br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 300\text{ }\mu\text{Adc}$ ) | $V_{GS(th)}$ | 2   | 2.8  | 4   | Vdc             |
| Gate Quiescent Voltage <sup>(3)</sup><br>( $V_{DS} = 28\text{ Vdc}$ , $I_D = 2200\text{ mAdc}$ )         | $V_{GS(Q)}$  | 3   | 3.8  | 5   | Vdc             |
| Drain-Source On-Voltage <sup>(1)</sup><br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 3\text{ Adc}$ )            | $V_{DS(on)}$ | —   | 0.26 | 0.3 | Vdc             |
| Forward Transconductance <sup>(1)</sup><br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 3\text{ Adc}$ )           | $g_{fs}$     | —   | 7.5  | —   | S               |
| <b>Dynamic Characteristics</b> <sup>(1,2)</sup>                                                          |              |     |      |     |                 |
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0$ , $f = 1\text{ MHz}$ )         | $C_{rss}$    | —   | 2.75 | —   | pF              |

**Functional Tests** <sup>(3)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 2200\text{ mA}$ ,  $P_{out} = 52\text{ W Avg.}$ ,  $f_1 = 2157.5\text{ MHz}$ ,  $f_2 = 2167.5\text{ MHz}$ , 2-Carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset. IM3 measured in 3.84 MHz Bandwidth @  $\pm 10\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

|                              |          |      |     |     |     |
|------------------------------|----------|------|-----|-----|-----|
| Power Gain                   | $G_{ps}$ | 12   | 13  | —   | dB  |
| Drain Efficiency             | $\eta_D$ | 22.5 | 24  | —   | %   |
| Intermodulation Distortion   | IM3      | —    | -36 | -34 | dBc |
| Adjacent Channel Power Ratio | ACPR     | —    | -39 | -37 | dBc |
| Input Return Loss            | IRL      | —    | -12 | -9  | dB  |

- Each side of device measured separately.
- Part internally matched both on input and output.
- Measurement made with device in push-pull configuration.



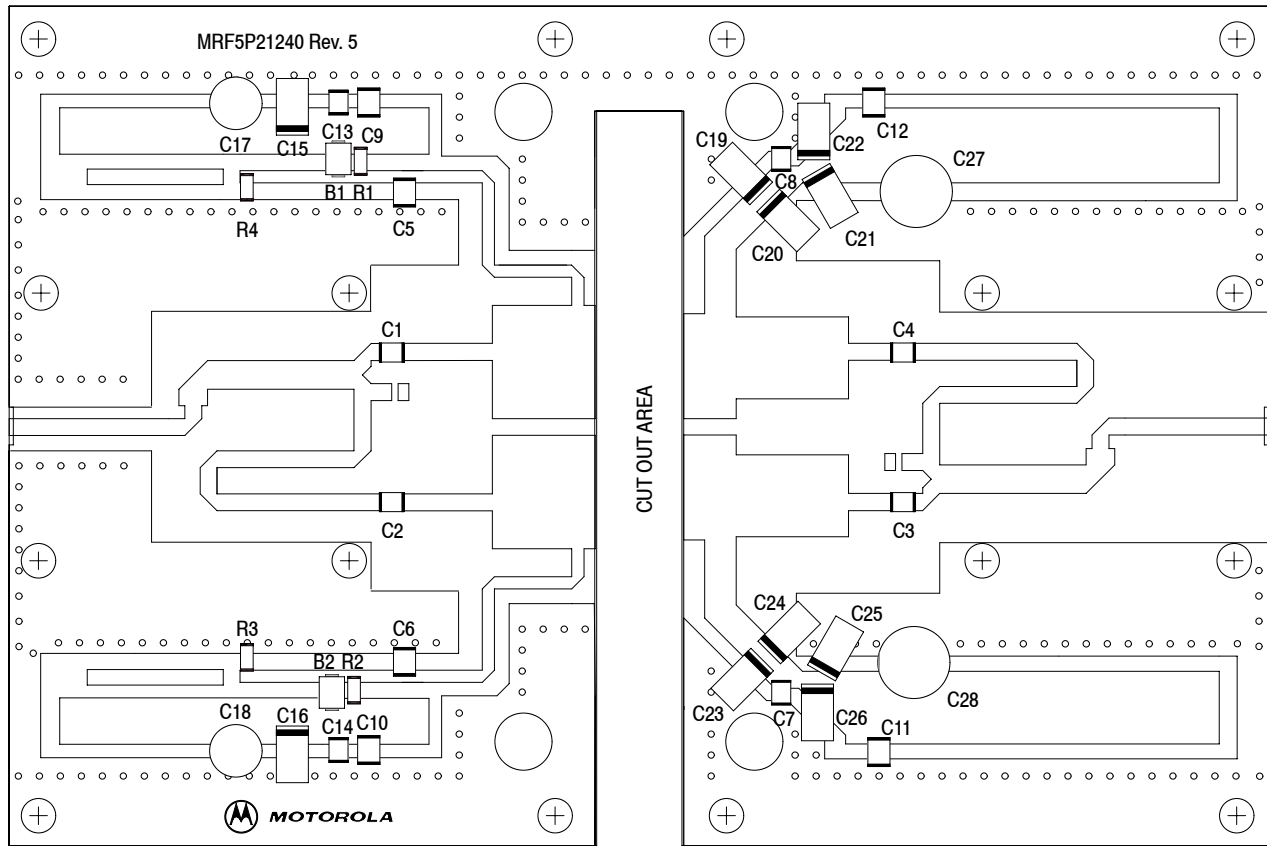
Z1 0.898" x 0.080" Microstrip  
 Z2, Z23 0.775" x 0.136" Microstrip  
 Z3, Z22 0.060" x 0.080" Microstrip  
 Z4, Z21 1.867" x 0.080" Microstrip  
 Z5, Z6 0.443" x 0.080" Microstrip  
 Z7, Z8 0.100" x 0.080" Microstrip  
 Z9, Z10 0.490" x 0.540" Microstrip

Z11, Z12 1.270" x 0.058" Microstrip  
 Z13, Z14 0.250" x 0.500" Microstrip  
 Z15, Z16 0.850" x 0.150" Microstrip  
 Z17, Z18 0.535" x 0.390" Microstrip  
 Z19, Z20 0.218" x 0.080" Microstrip  
 Z24 0.825" x 0.080" Microstrip  
 PCB Arlon GX-0300-55-22, 0.030",  $\epsilon_r = 2.55$

Figure 1. MRF5P21240HR6 Test Circuit Schematic

Table 5. MRF5P21240HR6 Test Circuit Component Designations and Values

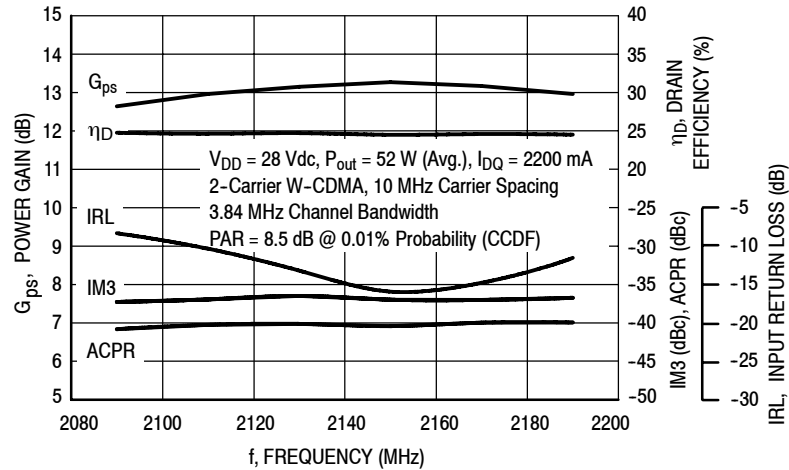
| Part                                     | Description                               | Part Number        | Manufacturer     |
|------------------------------------------|-------------------------------------------|--------------------|------------------|
| B1, B2                                   | Short Ferrite Beads                       | 2743019447         | Fair-Rite        |
| C1, C2, C3, C4                           | 18 pF Chip Capacitors                     | ATC100B180JCT500XT | ATC              |
| C5, C6, C7, C8                           | 6.8 pF Chip Capacitors                    | ATC100B6R8JCT500XT | ATC              |
| C9, C10, C11, C12                        | 0.1 $\mu$ F Chip Capacitors               | CDR33BX104AKWS     | Kemet            |
| C13, C14                                 | 1000 pF Chip Capacitors                   | ATC100B102JCT500XT | ATC              |
| C15, C16                                 | 4.7 $\mu$ F Tantalum Capacitors           | T491C475M050AT     | Kemet            |
| C17, C18                                 | 10 $\mu$ F, 50 V Electrolytic Capacitors  | EMVY500ADA100MF55G | Nippon Chemi-Con |
| C19, C20, C21, C22<br>C23, C24, C25, C26 | 22 $\mu$ F Tantalum Capacitors            | T491X226K035       | Kemet            |
| C27, C28                                 | 100 $\mu$ F, 50 V Electrolytic Capacitors | EMVY500ADA101MHA0G | Nippon Chemi-Con |
| R1, R2                                   | 1 k $\Omega$ , 1/4 W Chip Resistors       | CRCW12061001FKEA   | Vishay           |
| R3, R4                                   | 10 $\Omega$ , 1/4 W Chip Resistors        | CRCW120610R0FKEA   | Vishay           |



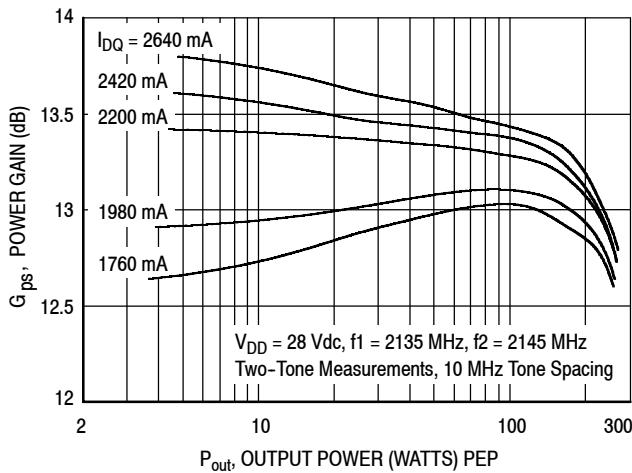
Freescall has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescall Semiconductor signature/logo. PCBs may have either Motorola or Freescall markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 2. MRF5P21240HR6 Test Circuit Component Layout**

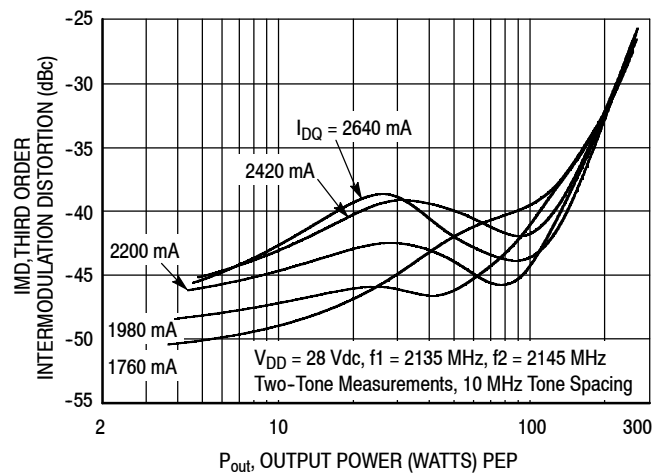
## TYPICAL CHARACTERISTICS



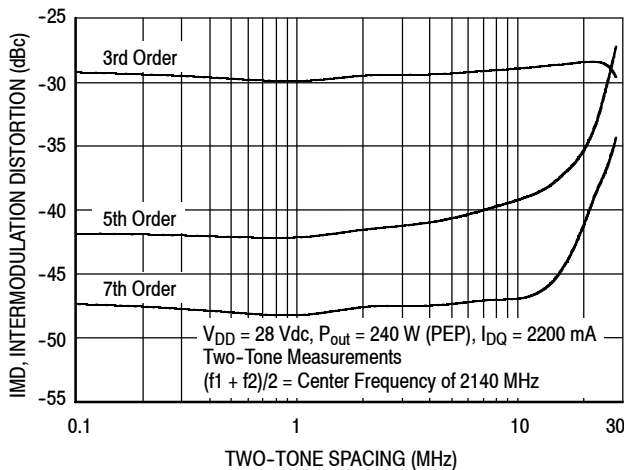
**Figure 3. 2-Carrier W-CDMA Broadband Performance  
@  $P_{out} = 52$  Watts Avg.**



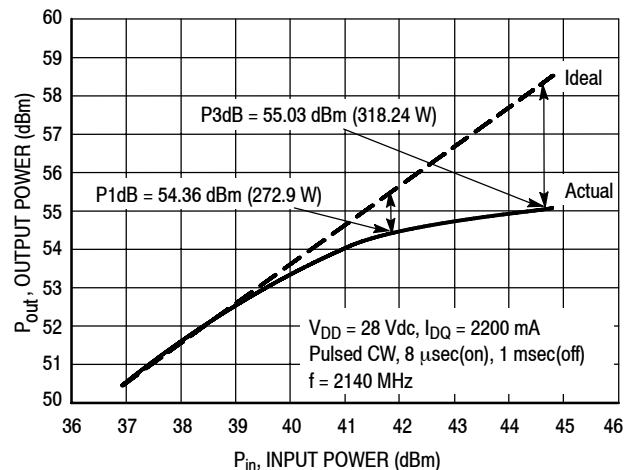
**Figure 4. Two-Tone Power Gain versus  
Output Power**



**Figure 5. Third Order Intermodulation Distortion  
versus Output Power**

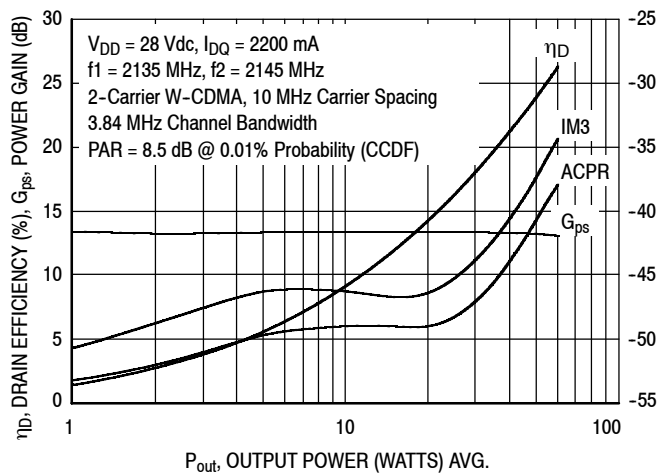


**Figure 6. Intermodulation Distortion Products  
versus Tone Spacing**

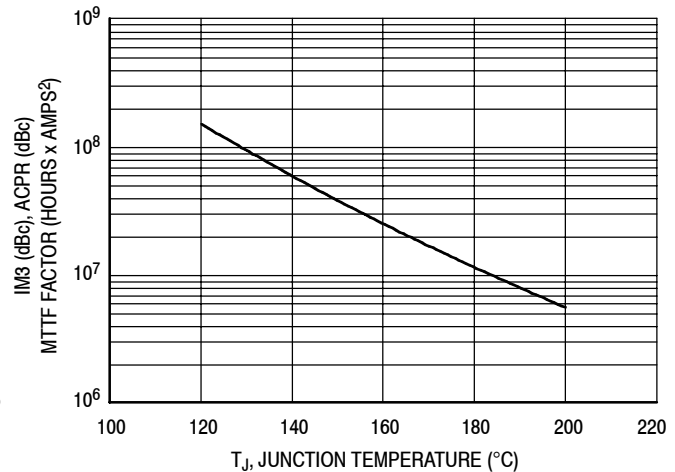


**Figure 7. Pulse CW Output Power versus  
Input Power**

## TYPICAL CHARACTERISTICS



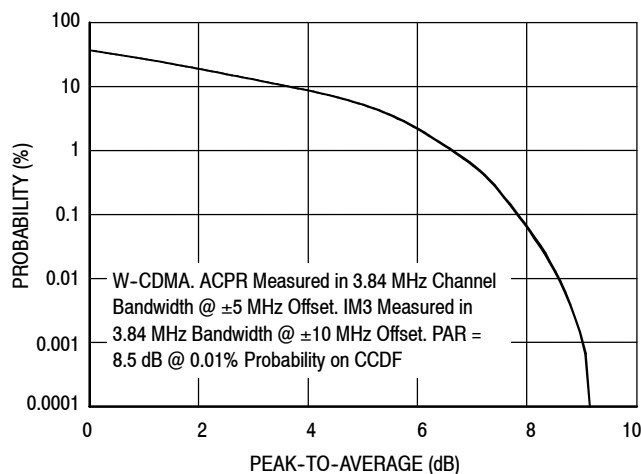
**Figure 8. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**



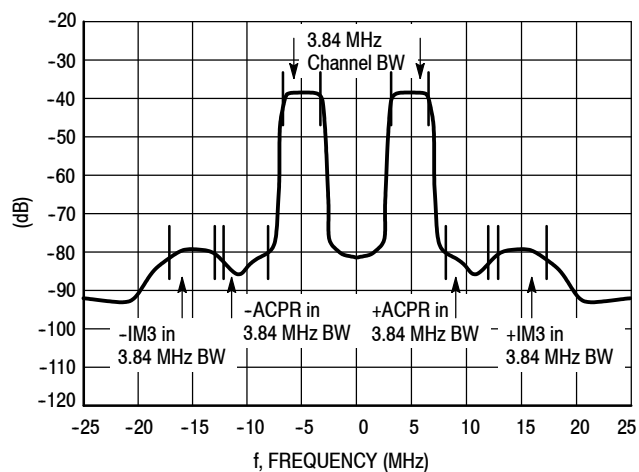
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

**Figure 9. MTTF Factor versus Junction Temperature**

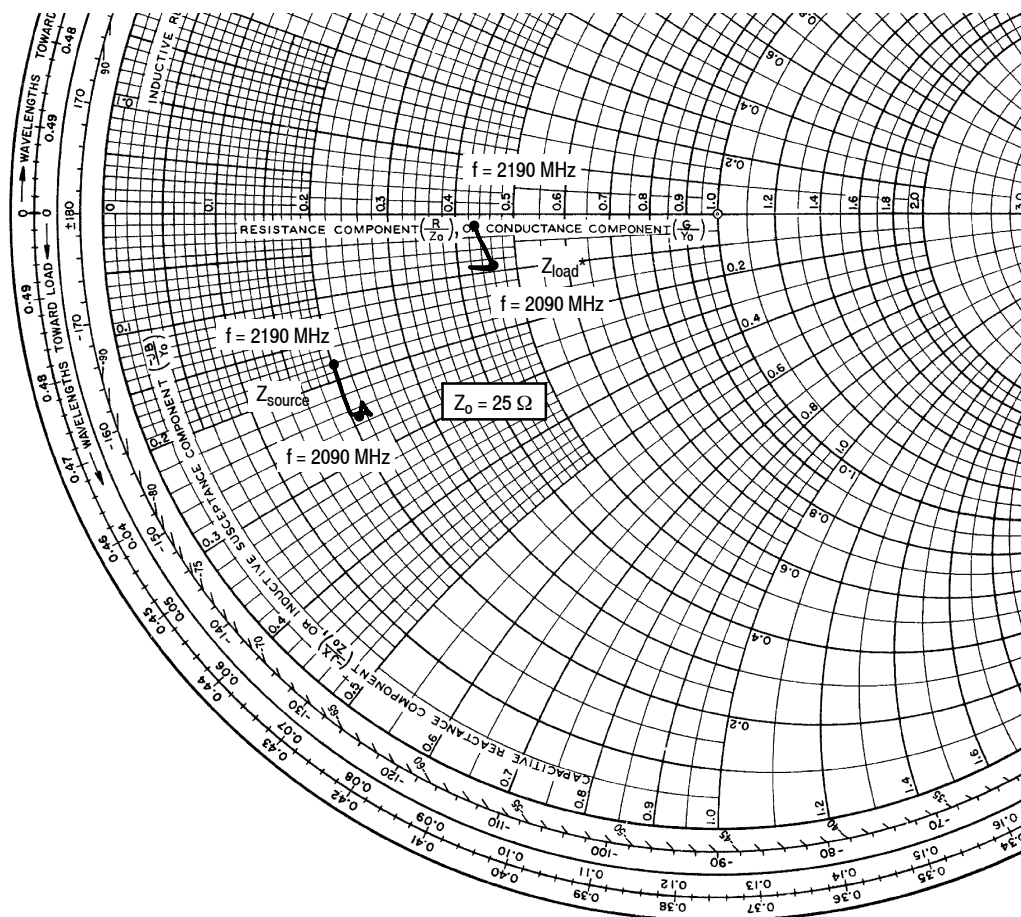
## W-CDMA TEST SIGNAL



**Figure 10. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 67% Clipping, Single-Carrier Test Signal**



**Figure 11. 2-Carrier W-CDMA Spectrum**



$V_{DD} = 28$  Vdc,  $I_{DQ} = 2200$  mA,  $P_{out} = 52$  W Avg.

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 2090     | $5.33 - j6.21$           | $11.42 - j2.25$        |
| 2110     | $5.44 - j5.88$           | $10.45 - j2.16$        |
| 2130     | $5.40 - j6.16$           | $11.28 - j2.14$        |
| 2150     | $5.12 - j6.06$           | $11.38 - j2.14$        |
| 2170     | $4.96 - j5.25$           | $11.04 - j1.25$        |
| 2190     | $4.98 - j4.47$           | $10.73 - j0.40$        |

$Z_{source}$  = Test circuit impedance as measured from gate to gate, balanced configuration.

$Z_{load}$  = Test circuit impedance as measured from drain to drain, balanced configuration.

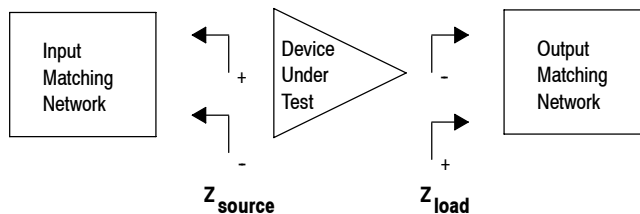
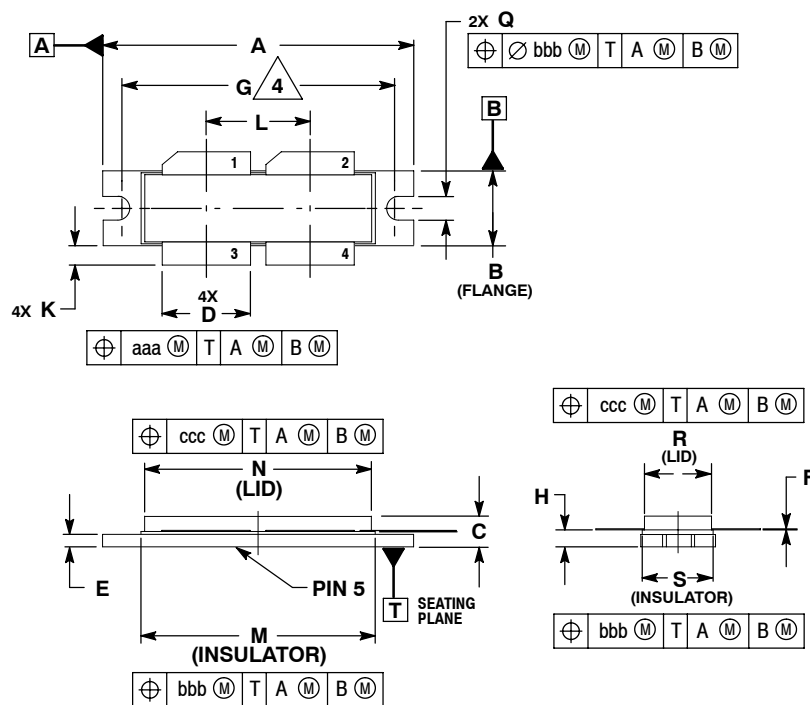


Figure 12. Series Equivalent Source and Load Impedance

## PACKAGE DIMENSIONS



### NOTES:

1. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.
4. RECOMMENDED BOLT CENTER DIMENSION OF 1.52 (38.61) BASED ON M3 SCREW.

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 1.615     | 1.625 | 41.02       | 41.28 |
| B   | 0.395     | 0.405 | 10.03       | 10.29 |
| C   | 0.150     | 0.200 | 3.81        | 5.08  |
| D   | 0.455     | 0.465 | 11.56       | 11.81 |
| E   | 0.062     | 0.066 | 1.57        | 1.68  |
| F   | 0.004     | 0.007 | 0.10        | 0.18  |
| G   | 1.400 BSC |       | 35.56 BSC   |       |
| H   | 0.082     | 0.090 | 2.08        | 2.29  |
| K   | 0.117     | 0.137 | 2.97        | 3.48  |
| L   | 0.540 BSC |       | 13.72 BSC   |       |
| M   | 1.219     | 1.241 | 30.96       | 31.52 |
| N   | 1.218     | 1.242 | 30.94       | 31.55 |
| Q   | 0.120     | 0.130 | 3.05        | 3.30  |
| R   | 0.355     | 0.365 | 9.01        | 9.27  |
| S   | 0.365     | 0.375 | 9.27        | 9.53  |
| aaa | 0.013 REF |       | 0.33 REF    |       |
| bbb | 0.010 REF |       | 0.25 REF    |       |
| ccc | 0.020 REF |       | 0.51 REF    |       |

### STYLE 1:

- PIN 1. DRAIN
- DRAIN
- GATE
- GATE
- SOURCE

CASE 375D-05  
ISSUE E  
NI-1230

REVISION HISTORY

The following table summarizes revisions to this document.

| Revision | Date      | Description                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2        | Oct. 2008 | <ul style="list-style-type: none"><li>Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN12779, p. 1, 2</li><li>Updated Part Numbers in Table 5, Component Designations and Values, to RoHS compliant part numbers, p. 3</li><li>Added Product Documentation and Revision History, p. 9</li><li>Data sheet archived. Part no longer manufactured.</li></ul> |

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ARCHIVE INFORMATION

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Freescale Semiconductor Japan Ltd.  
Headquarters  
ARCO Tower 15F  
1-8-1, Shimo-Meguro, Meguro-ku,  
Tokyo 153-0064  
Japan  
0120 191014 or +81 3 5437 9125  
[support.japan@freescale.com](mailto:support.japan@freescale.com)

### Asia/Pacific:

Freescale Semiconductor China Ltd.  
Exchange Building 23F  
No. 118 Jianguo Road  
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